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block-based motion vectors
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PARENT-CASE:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S.
application Ser. No. 09/335,810,
filed on Jun. 18, 1999, abandoned, and claims the
benefit of the filing date
of U.S. provisional application No. 60/121,531,
filed on Feb. 25, 1999.

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Abstract Text - ABTX (1):

An input encoded video bitstream conforming to a
first DCT-based image
compression standard (e.g., MJPEG or DV) is
converted into an output encoded
video bitstream conforming to a second DCT-based

image compression standard (e.g., MPEG) without having to fully decode the first bitstream according to the first image compression standard and without having to fully encode according to the second image compression standard in order to generate the output bitstream. Rather, a **partial video decoder** of a transcoding system applies steps of the first image compression standard to the input bitstream to generate dequantized DCT coefficient data. A DCT data converter of the transcoding system then processes the dequantized DCT coefficient data in the DCT domain as necessary to enable a partial video encoder of the transcoding system to apply steps of the second image compression standard to the converted DCT coefficient data in order to generate the output bitstream. The processing performed in the DCT domain by the partial video encoder includes motion estimation at block boundaries.

Brief Summary Text - BSTX (14):

The present invention is directed to techniques for transcoding input encoded video bitstreams conforming to a first DCT-based image compression standard (e.g., MJPEG or DV) into output encoded video bitstreams conforming to a second DCT-based image compression standard (e.g., MPEG). As opposed to brute-force transcoding techniques in which an input bitstream is fully decoded and then fully re-encoded to generate an output bitstream, under the present invention, the input bitstream is only **partially**

decoded according to the first standard into the DCT domain (i.e., dequantized DCT coefficients), and then the re-encoding processing for the second standard starts with those dequantized DCT coefficients to generate the output bitstream. Because transcoders of the present invention only perform part of the full decoding and encoding processes, which do not include application of the computationally expensive inverse and forward DCT transforms, these transcoders can be implemented using PC-based software-only solutions and still meet the throughput requirements of many real-time applications. As such, the expense of requiring full decoders and encoders is avoided by the present invention.

Detailed Description Text - DETX (3):

FIG. 1 shows a block diagram of a transcoding system 100, according to one embodiment of the present invention. Transcoding system 100 converts an input encoded video bitstream conforming to a first image compression standard (e.g., MJPEG or DV) into an output encoded video bitstream conforming to a second image compression standard (e.g., MPEG). Transcoding system 100 comprises a **partial video decoder** 102, a DCT data converter 104, and a partial video encoder 106. Depending on the particular implementation, the various components of transcoding system 100 can be implemented in software, hardware, or a combination of both.

Detailed Description Text - DETX (4):

In particular, **partial video decoder** 102 applies processing conforming to the first image processing standard (e.g., variable-length decoding, run-length **decoding, and dequantization)** to partially decode the input encoded video bitstream into dequantized DCT coefficient data. DCT data converter 104 converts the dequantized DCT coefficient data generated by **partial video decoder** 102 into corresponding converted DCT coefficient data for partial video encoder 106, which applies processing conforming to the second image compression standard (e.g., quantization, run-length encoding, and variable-length encoding) to the converted DCT coefficient data to generate the output encoded video bitstream.

Detailed Description Text - DETX (5):

The processing performed by **partial video decoder** 102 may comprise any suitable conventional processing techniques conforming to the first image processing standard in order to generate the decoded DCT coefficient data from the input encoded video bitstream. The processing performed by DCT data converter 104 in accordance with the present invention will depend on the particular video standards of the input and output encoded video bitstreams. Depending on the implementation, some or all of the processing of DCT data converter 104 may be optional. Depending on the implementation, the processing performed by partial video encoder 106 may comprise

any suitable conventional processing techniques conforming to the second image processing standard or it may comprise special processing techniques in accordance with the present invention. The processing of DCT data converter 104 and those portions of the processing of partial video encoder 106 that are part of the present invention are described in the following sections.

Detailed Description Text - DETX (9):

where X is a 16.times.16 block of dequantized DCT coefficients formed by concatenating a 2.times.2 region of four 8.times.8 blocks of dequantized DCT coefficients generated by partial video decoder 102, T is an 8.times.16 transformation matrix, T.sup.t is the 16.times.8 transpose of T, and Y is the resulting 8.times.8 block of converted DCT coefficients.

Detailed Description Text - DETX (23):

FIGS. 2A-C and 3A-C show the relative sizes for corresponding regions of pixel data for the YUV 4:1:1 and YUV 4:2:0 color formats. As shown in FIGS. 2A-C, for an H.times.W luma (Y) image, there are two H.times.W/4 chroma (U and V) images. As shown in FIGS. 3A-C, for an H.times.W luma image, there are two H/2.times.W/2 chroma images. In order for MPEG-compliant partial video encoder 106 of FIG. 1 to be able to generate an output bitstream conforming to the MPEG standard (which does not support the 4:1:1 color format), DCT data converter

104 is capable of converting dequantized DCT coefficient data generated by DV-compliant **partial video decoder** 102 from the YUV 4:1:1 color format into the YUV 4:2:0 color format, which can be handled by MPEG-compliant partial video encoder 106.

Detailed Description Text - DETX (25):

where X is a 16.times.8 block of chroma (U or V) DCT coefficient data formed by vertically concatenating two 8.times.8 blocks of chroma DCT coefficient data generated by **partial video decoder** 102 of FIG. 1, T.sub.c is a 8.times.16 column-wise transformation matrix, T.sub.r is an 8.times.16 row-wise transformation matrix, and Y is the resulting 8.times.16 block of transformed chroma DCT coefficient data.

Detailed Description Text - DETX (32):

Another major difference between DV bitstreams and MPEG bitstreams is the possible existence of encoded video data in a DV bitstream that was encoded based on the DV 2-4.times.8 mode. In order for MPEG-compliant partial video encoder 106 of FIG. 1 to be able to generate an output bitstream conforming to the MPEG standard (which does not support the 2-4.times.8 mode), DCT data converter 104 is capable of converting dequantized DCT coefficient data generated by DV-compliant **partial video decoder** 102 from 2-4.times.8 mode to 8.times.8 mode, which can be handled by MPEG-compliant partial video encoder

106.

Detailed Description Text - DETX (34):

where $X_{sub.e}$ and $X_{sub.o}$ are corresponding 4.times.8 blocks of even and odd DCT coefficients as defined by Equations (1) and (2), respectively, and generated by **partial video decoder** 102 of FIG. 1. The 8.times.4 transformation matrices $T_{sub.1}$ and $T_{sub.2}$ can be represented by Equations (19) and (20) as follows:

Detailed Description Text - DETX (38):

When implementing the matrix multiplication transformation of Equation (18), DCT data converter 104 of FIG. 1 converts each corresponding pair of even and odd 4.times.8 DCT blocks (i.e., $X_{sub.e}$ and $X_{sub.o}$) generated by **partial video decoder** 102 into a single 8.times.8 block of DCT coefficients (Y) for processing by partial video encoder 106.

Detailed Description Text - DETX (41):

The following sections describe some of processing techniques performed by partial video encoder 106 of transcoder 100 of FIG. 1, when the input encoded video bitstream is either an MJPEG or DV bitstream and the output encoded video bitstream is an MPEG bitstream, according to one embodiment of the present invention. These processing techniques relate to requantization for rate-control, inter-frame encoding in the DCT domain, motion compensation in

the DCT domain, inter/intra mode decision in the DCT domain, and field/frame mode decision in the DCT domain. As described below, all of these techniques involve manipulating the DCT coefficient data generated by partial video decoder 102 and/or DCT data converter 104 of FIG. 1.

Detailed Description Text - DETX (43):

Depending on the particular application, there may be a need to reduce the number of bits used to represent the video content in the output encoded video bitstream, even after the resizing operations of DCT data converter 104 are implemented. One way to control the bit rate of the output bitstream is to adjust the quantization levels used during the requantization processing performed by partial video encoder 106. According to the MJPEG and DV standards, every block (or macroblock) in an MJPEG or DV file is encoded using the same quantization level. On the other hand, the MPEG standards allow the quantization level to vary from frame to frame and even from macroblock to macroblock within a frame. Thus, during MJPEG-to-MPEG transcoding, the possibility exists for partial video encoder 106 to vary quantization level on a macroblock basis from the MJPEG quantization level used by partial video decoder 102 in generating the dequantized DCT coefficients.

Detailed Description Text - DETX (45):

where y is the corresponding dequantized DCT coefficient generated by **partial video decoder** 102 and optionally converted by DCT data converter 104, Q_{jpeg} is the quantization level at which the original MJPEG DCT coefficient data was quantized, and Q_{mpeg} is the selected MPEG quantization level for the current macroblock, where Q_{mpeg} may be represented by Equation (24) as follows:

Detailed Description Text - DETX (46):

where Q_{mpeg} is rounded to the nearest integer (or alternatively truncated) and **clipped** to the range $[1, 31]$, r is a reaction parameter that is typically set to twice the **bit** count of the original MJPEG (or DV) frame, and the discrepancy d in Equation (24) may be represented by Equation (25) as follows:

Detailed Description Text - DETX (59):

Another mode decision supported by the MPEG standard is the field/frame mode decision in which it is determined whether to encode an image as a single frame or separated into the upper and lower fields of a single interleaved image. In conventional MPEG algorithms, the field/frame mode decision is made in the pixel domain. According to embodiments of the present invention, the field/frame mode decision is made in the DCT domain by comparing the variance for the frame DCT mode to the variance for the field DCT mode and selecting the mode having the smaller variance. For DV and MJPEG input bitstreams, the

dequantized DCT coefficient data generated by **partial video decoder** 102 will already be structured in frame format. As such, the variance Vframe for the frame DCT mode can be computed directly from that dequantized DCT coefficient data using Equations (26) and (27).

Detailed Description Text - DETX (64):

FIG. 4 shows a flow diagram of the DV-to-MPEG transcoding processing performed by transcoding system 100 of FIG. 1, according to one embodiment of the present invention. Transcoding processing begins with **partial video decoder 102 of FIG. 1 partially decoding** an input encoded video bitstream conforming to the DV standard to generate a set of dequantized DCT coefficients for each frame of DV-encoded data (step 402).

Claims Text - CLTX (13):

13. A transcoding system for converting an input encoded video bitstream conforming to a first DCT-based compression algorithm into an output encoded video bitstream conforming to a second DCT-based compression algorithm different from the first compression algorithm, comprising: (a) a **partial video decoder** configured to apply decoding steps conforming to the first compression algorithm to the input bitstream to generate dequantized DCT coefficient data in a DCT domain; and (b) a partial video encoder configured to: (1) perform motion-compensated inter-frame differencing on the dequantized DCT coefficient

data in the DGT domain based on motion vectors
corresponding to block
boundaries without performing an inverse transform;
and (2) apply encoding
steps conforming to the second compression
algorithm to the motion-compensated
inter-frame DCT coefficient difference data to
generate the output bitstream.